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Total Quality Management and Nuclear Weapons

A Historian's Perspective

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by

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Abstract

Total Quality Management (TQM) has become a significant management theme at Los Alamos National Laboratory. This paper discusses the historical roots of TQM at Los Alamos and how TQM has been used in the development of nuclear weapons.

Introduction

Total Quality Management (TQM) is a philosophy of management that emphasizes continuous improvement of products and services.[1] Many of the concepts and techniques associated with Total Quality Management such as the use of multidisciplinary teams, simultaneous engineering, conflict management, and strong leadership have been practiced by major scientific laboratories throughout the world for over fifty years. Total Quality Management was the accepted norm for organizing and operating the first great American physics laboratory, the University of California's Lawrence Berkeley Laboratory, and was subsequently used by J. Robert Oppenheimer to organize the Los Alamos

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[1] Joseph E. Champoux and Joseph R. Jablonski, "Overview of Total Quality Management," The University of New Mexico, 1990.

laboratory in 1943. Despite its initial success at Los Alamos, the continued use of TQM by the Laboratory is not automatic. The TQM philosophy must be constantly and consciously employed to be effective.

At 5:29:45 a.m. on the morning of 16 July 1945, the world's first nuclear detonation took place in a desolate area of New Mexico known as the Jornada del Muerto—the Journey of Death. The detonation, dubbed the Trinity Test, culminated twenty-eight months of intensive scientific research and development by the Los Alamos laboratory. As the blast wave passed the nearest observers, who were ten miles away, Oppenheimer recalled a passage from the Bhagavad Gita: "I am become Death, the destroyer of worlds."[2] Harvard physicist Kenneth Bainbridge, the test director, was more blunt, saying: "Now we are all sons of bitches."[3] The Trinity test proved that man could build nuclear weapons. More significantly, the test demonstrated that almost any nation, if committed, could build such devices. The Trinity test made proliferation a reality. Russia exploded its first nuclear device in 1949 followed by Great Britain (1952), France (1960), and China (1964). United States intelligence experts believe that Israel has developed, but not tested, both fission

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[2] Ferenc Morton Szasz, The Day the Sun Rose Twice (Albuquerque: University of New Mexico Press, 1984), 89.

[3] Kenneth Bainbridge, "A Foul and Awesome Display," Bulletin of Atomic Scientists (May 1975):47.

and thermonuclear devices as well.[4] In March 1993, South Africa announced that it had built six fission weapons beginning in the 1970s.[5] Also in March 1993, Seymour Hersh reported that not only did India and Pakistan have nuclear weapons, but that these two countries came perilously close to a nuclear exchange in 1990.[6] Intelligence experts also believe that India, Brazil, Argentina, and Iraq are working extremely hard to develop or acquire nuclear weapons.[7]

TQM and Bomb Building

Total Quality Management is related to the existence and continuing proliferation of nuclear weapons in four areas: the building of nuclear bombs, weapons testing, global safety, and technological advances in weapons development.

When the Los Alamos Laboratory was formally established in the spring of 1943, it quickly became apparent to the newly

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[4] For a discussion of proliferation and the issue of an Israeli device see: McGeorge Bundy, Danger and Survival (New York: Random House, 1988), 463-516 and Seymour M. Hersh, The Samson Option (New York: Random House, 1991). For a discussion of the Chinese bomb, see John Wilson Lewis and Xue Litai, China Builds the Bomb (Stanford: Stanford University Press, 1988), 170-189.

[5] Albuquerque Journal, 25 March 1993 and 26 March 1993; New York Times, 25 March 1993.

[6] Hersh, Seymour M., "On the Nuclear Edge," The New Yorker (March 29, 1993): 56-73.

[7] Bundy, 515.; A quick review of major newspapers between 1991 and 1993 will give a good overview of the Iraqi situation.

appointed director, J. Robert Oppenheimer, that no single scientific discipline could provide all of the expertise necessary for developing an atomic bomb.[8] So little was known about nuclear chain reactions that the entire sum of the world's knowledge about an atomic bomb was contained in a document only twenty-four pages long.[9] If a bomb was to be developed and made available for war use—the stated mission of the Laboratory—Oppenheimer had to recruit chemists, metallurgists, mathematicians, engineers, military ordnance personnel, and physicists to solve the seemingly infinite number of problems related to an atomic device. The two relatively simple bombs developed during World War II required special materials, electronic circuits, and high explosives—all of which were only recently discovered or nonexistent in 1943.

Multidisciplinary Teams

Oppenheimer had no qualms about hiring and using scientists and engineers from the many disciplines. As a theoretical physicist at the Berkeley campus of the University of California, he assisted Nobel Laureate and experimental physicist Ernest Lawrence in making the Berkeley physics laboratory the major

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[8] Hoddeson, Lillian H., Roger A. Meade, Paul W. Henriksen, and Catherine Westfall. Critical Assembly: A Technical History of Los Alamos During the Oppenheimer Years, 1943-1945 (New York: Cambridge University Press, 1993), 403-417; and Hawkins, David, Project Y: The Los Alamos Story(Los Angeles: Tomas Publishers, 1983), 34-43.

[9] Robert Serber, The Los Alamos Primer (Berkeley, Ca., The University of California Press, 1992).

force in physics research. At the Berkeley laboratory, Oppenheimer worked closely with experimental physicists as well as chemists, engineers, and machinists. Machinists were highly valued because they were the only people who could produce the apparatus of physicists' dreams. Everyone at the laboratory worked together in teams. The results produced by the Los Alamos teams remain legend in international scientific community. By 1940, two transuranium elements, neptunium and plutonium, were discovered, the first cyclotrons were built, and three scientists were awarded Nobel prizes. Oppenheimer transplanted the concept of multidisciplinary teams to Los Alamos. The formal organization chart of Los Alamos in 1943 depicts a classic functional organization consisting of divisions for theoretical physics, chemistry and metallurgy research, experimental physics, and ordnance engineering. In reality, the laboratory operated around large teams working on gun assembly, implosion assembly, and basic nuclear research. Each division contributed staff for each of these teams. The results, as in the Berkeley experience, were dramatic. Between June 1943 and July 1945, two atomic bombs of radically different design were conceived, developed, and produced without any prior knowledge of how to conduct such work.

The power and vitality of the Laboratory's multidisciplinary teams were demonstrated in the early summer of 1944. Experiments revealed that a slight isotopic impurity in plutonium would cause spontaneous fissioning, or premature detonation, if the assembly speed was too slow. Such impurities could not be eliminated. Spontaneous fissioning of plutonium would produce a dud and therefore made the use of plutonium impossible in the only sure method of assembly available—the gun method. This discovery created a crisis. The Oak Ridge, Tennessee, uranium production plant could not possibly produce enough uranium to compensate for the loss of the planned use of plutonium. If plutonium could not be used in a weapon, the war effort of Los Alamos and the entire Manhattan Project was in danger of being seriously crippled. Oppenheimer responded by reorganizing the Laboratory in August 1944 and redirecting all research teams but one to develop a method capable of using plutonium-implosion assembly. Although under investigation from the beginning, implosion had received little attention and was not considered practical. Less than one year after redirecting team efforts, the implosion bomb became a reality.

It is interesting to note the role of communications in the development of implosion assembly since open communication is itself a key factor in TQM efforts. From the very beginnings of the Los Alamos Project, implosion had a champion—Seth Neddermeyer. Unfortunately, Neddermeyer was junior to most physicists on the project and was not capable of expressing himself forcefully. As a result, Oppenheimer, among others, did not take Neddermeyer seriously. Early in 1944 implosion acquired a forceful and highly respected champion, John von Neumann.

Considered one of the greatest mathematicians in the world, von Neumann occasionally visited Los Alamos as a personal consultant to Oppenheimer. During one of his visits, von Neumann commented that implosion was important and should be pursued. Based on von Neumann's observation, implosion survived. The lesson appears obvious—do not discount ideas from junior staff.[10]

Not only did Oppenheimer use multidisciplinary teams to conduct scientific work, he also used such teams to manage the Laboratory itself. Some teams, such as the "Cowpuncher" Committee, provided direct, technical oversight of specific projects.[11] Other teams, including the Administrative Board, looked after the Laboratory as a whole and kept all work focussed on the Laboratory's mission. Although Oppenheimer had to accept all responsibility for the successes and failures of the Laboratory, in reality all major decisions were made by teams. Recently, historians have tried to apportion individual credit for the major wartime technical successes of the Laboratory. However, they are constantly rebuffed by people as prestigious as Hans Bethe, Edward Teller, and former Atomic Energy Commissioner Robert Bacher. As Bacher stated in an interview: "We operated as

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[10] Critical Assembly, p. 129.

[11] The Cowpuncher Committee had the explicit mission of "riding herd" on the implosion program. Hence, its name. Los Alamos National Laboratory Archives, Collection A-83-013, Box 2, Folder 62.

a team. If we didn't, we would have failed."[12]

Conflict Management

The second TQM principle that science and scientific laboratories have practiced since the early 1900s is conflict management. All science is conflict. Research findings, when published, are subjected to continual, often brutal, challenges. These challenges continue until the findings are validated or disproved. Some very important discoveries, fission for example, are quickly challenged and proved.[13] Other research, such as cold fusion, suffers under the conflict of peer review. Conflict management is a basic principle of science which guarantees the advancement of science.

Major General Leslie Groves, head of the Manhattan Engineering District, was paranoid about security throughout his command. As the head of America's World War II nuclear efforts, Groves fought any exchange of information between the many laboratories and, more importantly, within each laboratory. The lack of full and frank discussions between the respective laboratories translated into a lack of scientific conflict and was counterproductive. In 1944 Groves' policy almost caused a disaster at Oak Ridge. Without full interchange of information

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[12] Private Communication, Robert Bacher, Los Alamos, New Mexico, 1988.

[13] Rhodes, Richard, The Making of the Atomic Bomb. New York: Simon and Schuster, 269-275.

between the production facilities at Oak Ridge and the research facilities at Los Alamos, Oak Ridge personnel did not have access to the most up-to-date information on the critical mass of U-235—a number which kept changing. Since the uranium production plant at Oak Ridge did not have access to the basic research on uranium being conducted at Los Alamos, the plant's safety procedures for handling the metal were inadequate. Only a chance visit by Los Alamos physicist Richard Feynman saved Oak Ridge from an accident. Feynman had been invited to Oak Ridge to review plans for a new building. As he walked into the room where processed uranium was being stored, he realized that too much U-235 was being stored in too small a space—a condition that could lead to an explosion. Feynman's accidental discovery saved Oak Ridge from disaster.[14] Restrictions on exchanges of information between laboratories were relaxed, somewhat, in late 1944. Groves' change of heart came not because of the Oak Ridge incident, but rather from the increased interdependence of the individual laboratories. Groves wanted a bomb and exchange of information was the only way his success could be guaranteed.

Groves' restrictions on secrecy within each laboratory did, paradoxically, create conflict at Los Alamos. Telling scientists that they cannot talk to each other is futile, particularly when they have been instructed to produce a miracle in a very short

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[14] Feynman, Richard. Surely You're Joking Mr. Feynman (New York: Bantam Books, 1986), 103-108.

period of time. At the beginning of the Los Alamos Project, Oppenheimer planned to hold a series of weekly colloquia where research would be discussed. Groves forbade these colloquia and tried to keep each scientist figuratively and literally confined to an office. When Oppenheimer announced Groves' rule, he faced revolt. Many scientists, including present and future Nobel Laureates Fermi, Bethe, and Feynman threatened to quit. Faced with a revolt of such magnitude, Groves relented, and free and unencumbered access to colloquia was granted to staff and the colloquia were inaugurated.[15] Colloquia are still held.

Simultaneous Engineering

The third major Total Quality Management principle used in the early science laboratories and subsequently at Los Alamos was simultaneous engineering. Simultaneous engineering can be described as a process whereby all aspects of a product's or service's design, development, and delivery are related by continuous interaction among development teams. Such parallel development stands in opposition to serial development, where each step, such as design, is completed before the next step is started. Simultaneous engineering allows an organization to produce a quality product in the shortest possible time. At Los Alamos, simultaneous engineering allowed scientists to develop two completely different types of bombs in just twenty-eight months. By the 1960s, new weapon systems took as long as ten

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[15] Critical Assembly, p. 94.

years to develop.[16]

In 1943, Los Alamos scientists had only vague ideas of how to develop an atomic bomb. In terms of gross anatomy, the World War II bombs had major systems consisting of fissionable material, high explosives, detonation trains, and ballistic casings. All of these systems were non-existent when the war began. Had each of these major systems been developed and perfected in serial fashion, World War II might have ended without the Laboratory making a significant contribution. It is also probable that the war would have gone on for a longer period of time. However, using multidisciplinary teams and simultaneous engineering, the bombs were developed in time to aid the war effort. Each major system was developed concurrently with every other system with the stated purpose that all components would complement each other. Because the supply of fissionable material was very limited, the finished products had to work correctly the first time. The crisis of the war effort did not allow scientists the luxury of time. The demands of the war forced theoretical physicists to work closely with experimental physicists and each of these groups to work closely with engineers, chemists, and machinists.[17] Their success is directly attributable to simultaneous engineering.

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[16] "Weapons Program Management Handbook," Los Alamos National Laboratory Archives, VFA 518.

[17] Critical Assembly, p. 407.

TQM and Weapons Testing and Global Safety

Nuclear proliferation is a fact of life that cannot be undone in the foreseeable future. Atomic bombs are, for weaker nations, an equalizer. Unable to compete on an equal political footing such countries see "the bomb" as a means of acquiring attention and a voice in world affairs. Former Assistant Secretary of Defense, Richard Perle, argued this point in 1990:

> "American nuclear weapons in Europe, and specifically in West Germany, are crucial to the safety and stability of Europe. Without them, Germany would face the nuclear-armed Soviet Union with only non-nuclear forces. The result would be a dangerous imbalance in the center of Europe. And, whatever Germany may say or think today, this imbalance would in time lead Germany to seek nuclear weapons of its own."[18]

James H. Billington, the Librarian of Congress, wrote in his review of Andrei Sakharov's Memoirs: "The United States and Soviet Union will continue the arms race for another ten or fifteen years. Both sides, according to Billington, will need to have bargaining chips of real value to bring to any negotiations."[19] Although not much of a political prognosticator, Billington does capture the essence of the problem. Nuclear weapons are seen as equalizers and they will not be willingly given up. None of the former Soviet republics

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[18] Wall Street Journal, 1 May 1990.

[19] James H. Billington, New York Times Book Review, 17 June 1990.

has yet relinquished its nuclear weapons.

Testing

Since 1945, great strides have been made in adding to mankind's knowledge and understanding of nuclear detonations. The evolution of supercomputers and their use in weapons design and simulation has reduced the number of required tests. Despite the technical resources used to increase the understanding of nuclear reactions, much remains unknown. Computer simulation has not been able to overcome this vast amount of unknown information. A certain number of actual tests of nuclear devices are necessary to continue to fill in the gaps in our knowledge. As the leader of Los Alamos' Field Test Division once observed: "Truth can only be found at the bottom of a [test] shaft."[20]

The idea that weapons testing and Total Quality Management are linked by the concept of "commitment to quality" appears, at first glance, to be incongruous. After all, one of the goals of Total Quality Management is to move organizations away from the need to inspect and test for quality. Quality should be an intrinsic part of any product or service. If commitment to quality is defined in terms of reduced inspection (i.e, testing), then the link to weapons testing is indeed weak. If, however, commitment to quality is defined in terms of producing the best possible product, the link is strong. The final products of the

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[20] Interview, Jay Norman, May 1988.

two weapons design laboratories in the United States are not just bombs, but weapons systems that must be stored for years and remain capable of performing flawlessly. Such systems are constantly moved around the world as part of this nation's changing defense needs, with the concomitant amount of rough handling that goes with any move, and again expected to function flawlessly. Finally, these systems face a high statistical probability of being exposed to both natural and manmade disasters which they must survive intact. Given mankind's lack of a full understanding of nuclear reactions, the expectations that are required of the final product, and the overriding hope that such devices will never be used in war, testing is not inspection but rather the simulated end-use of a product. As a substitute for actual combat use, testing is the ultimate proof of a weapon's quality.

In 1960 the United States was in the middle of a test moratorium, one that had been painstakingly crafted by Dwight Eisenhower as the crowning achievement of his presidency.[21] In the middle of the moratorium, designers at Los Alamos discovered that some weapons systems might be inherently unsafe. A severe accident could cause one of these weapons to detonate. Because testing, by treaty, was banned, the United States could not

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[21] Hewlett, Richard G. and Jack M. Holl, Atoms for Peace and War (Berkeley: The University of California Press, 1989), 333-337 and Kistiakowsky, George B., A Scientist at the White House (Cambridge: Harvard University Press, 1976), 130.

simply begin testing even to improve safety. The continuing cold war with the Soviet Union made withdrawal of the systems from the stockpile unwise. Certainly, the problem could not be ignored. Eisenhower split the difference between these two positions and authorized a series of secret experiments designed to test the "one-point safety" of these systems. The defect, in general, was that a detonation at any single point on or in the explosive components of the warhead's trigger might cause a nuclear explosion. Without recourse to testing, Eisenhower had to risk a serious treaty violation and an ignominious end to his public life in order to guarantee the quality of the nation's nuclear deterrent.[22] Weapons testing, now much reduced by law and public opinion, could not be used to evaluate the full range of requirements that all nuclear weapons systems must meet.[23] Without the ability to simulate the "final product," nuclear weapons cannot be considered safe.

The total quality implications of weapons testing should not be construed as an argument for unrestricted testing. Rather, testing should be viewed as part of the process for insuring the quality of our nuclear weapons—weapons that are, unfortunately, necessary until they can be eliminated throughout the world.

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[22] Albuquerque Journal, 26 February 1987 and 28 February 1987.

[23] Time, 4 June 1990. Such problems continue to exist. Recently, three additional warheads came under suspicion of being unsafe. The lack of reliability or safety came not from the nuclear components but from the delivery systems.

Global Safety

TQM is linked to global safety in two ways. First is the safety issue raised by the very existence of nuclear weapons themselves. Any detonation of a nuclear weapon, accidental or purposeful, outside the confines of controlled testing could be disastrous. Faced with increased ethnic strife throughout the republics of the former Soviet Union, Russia has begun to centralize the Soviet stockpile of nuclear weapons.[24] If, as some scientists have speculated, all nuclear weapons, regardless of country of origin, are constructed in essentially the same fashion, some Soviet weapons, like their earlier American counterparts, could be unsafe.[25] TQM suggests at least two approaches to safeguarding world security in this arena. Strong leadership must be exercised by all nations involved, particularly Russia, the Ukraine, Kazakhstan, Tadzhikistan, and the United States. Leaders of these nations must take complete ownership for the custody and safeguarding of nuclear weapons as well as working cooperatively to stop any sales of nuclear weapons to non-nuclear countries. Recent press reports indicate that nuclear weapons may become a commodity to be bought and sold in the international arms bazaar.[26] If these accounts are

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[24] Wall Street Journal, 22 June 1990.

[25] Albuquerque Journal, 26 February 1987 and 28 February 1987. One scientist puts the percentage of unsafe weapons as high as 33 percent.

[26] As an example, see Los Alamos Monitor, 17 August 1990; The Wall Street Journal, 17 December 1991; and the Albuquerque Journal, 12 January 1992 and 19 January 1992.

accurate, strong leadership will be needed to stop such proliferation. Additionally, testing of Soviet warheads should be considered. Until these weapons can be eliminated, periodic detonations are the only way to be certain that stockpiled weapons are safe. If Total Quality Management is practiced, the probability of a detonation outside one of the world's nuclear test areas will be significantly lessened.

Second is the safety issue raised by terrorism. Terrorism is a brutal fact of life and comes in two forms: terrorism practiced by nation-states and terrorism practiced by parochial groups. The United States faced state sponsored nuclear terrorism in 1962 when the Soviet Union introduced intermediate range ballistic missiles in Cuba. The United States response—a naval blockade and quiet diplomacy—evolved from a series of brainstorming meetings between military, political, and diplomatic leaders assembled by President John F. Kennedy.[27] United States success in using a multidisciplinary team to solve the Cuban Missile Crisis was the result of an early Kennedy administration failure—the Bay of Pigs. Planning for the Bay of Pigs invasion also was done by a multidisciplinary group appointed by Kennedy. However, powerful political members of the planning team dominated discussions.[28] The result was the lack

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[27] Bundy, 391-462.

[28] For a detailed discussion of groupthink and the Bay of Pigs invasion, see Irving Janis' Victims of Groupthink: A Psychological Study of Foreign Policy Decisions and Fiascos.

of a full and frank discussion of the invasion. Negative opinions about the feasibility of the invasion were absolutely forbidden, a phenomenon known as "groupthink." Disaster followed and Kennedy learned a valuable lesson. Early in the Cuban Missile Crisis discussions, he insisted on full and frank participation by everyone involved.[29] The successful conclusion of the Cuban Missile Crisis is eloquent testimony to the use of teams if the problem of groupthink can be avoided.

Parochial terrorism directed against nuclear weapons is not yet a phenomenon in the United States. Unlike the republics of the former Soviet Union, the United States does not have to worry about ethnic nationalism being directed against its stockpile. The United States, however, is not immune from such terrorism as the recent bombing of the World Trade Center suggests. Government agencies, such as the Federal Bureau of Investigation, can profit from TQM principles such as brainstorming to prevent theft and sabotage of this nation's nuclear stockpile. Other useful TQM principles include the use of multidisciplinary teams to monitor terrorist activities as well as to devise plans and train agents to respond to terrorist activities.

Proliferation

Although the existence of nuclear weapons is a threat to global safety, a much more serious threat is proliferation.

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[29] Ibid.

Countries such as Iraq are trying hard to acquire nuclear weapons. Total Quality Management provides an interesting lesson for national defense and the response to Iraq particularly in the arena of leadership.

Leadership commitment to national defense, like leadership commitment to Total Quality Management efforts, is an absolute must. Without commitment, national defense suffers and the nation pays a high price to make up the deficit. As United States Senator Malcolm Wallop has pointed out: "Every time the U.S. has embarked on a drastic unilateral reduction in military capability for a short-term gain, the ultimate result has been a high cost—in American blood as well as treasure."[30] Drastic cuts were made in the United States' defense budgets immediately prior to the Civil War, Spanish-American War, World Wars I and II, the Korean Conflict, and, to a lesser extent, the Vietnam War. The lack of commitment to a strong and reasonable defense is correlated positively to aggression and war. In a time when the Warsaw Pact has been effectively destroyed, "The Soviets are modernizing and expanding their nuclear arsenal."[31] Although the republics that inherited the Soviet stockpile are not modernizing or expanding their arsenals, it is not clear that they consider custody a sacred trust. Without continued commitment to a strong, rational defense by American political leaders, the

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[30] Wall Street Journal, 2 August 1990.

[31] Ibid.

United States could face a repeat of its past.

In 1980, the Israeli air force destroyed a uranium production reactor outside of Baghdad. Although the raid was successful in destroying the partially built facility, it did not destroy the fissionable material that Saddam Hussein had acquired to begin building atomic bombs. Despite certain international condemnation, the Israeli leadership believed its safety, as well as the safety of the Persian Gulf region, would be compromised by an Iraq capable of building nuclear bombs. The international community did indeed condemn Israel, but the Israelis never wavered in their belief that they had acted correctly and responsibly.[32] Nine years later, the United States faced a similar situation. However tragic the invasion of Kuwait is, the real problem in the Middle East is the threat of an Iraq armed with nuclear weapons. In the years since the raid on the Osirak reactor, Iraq has been rebuilding its nuclear weapons plant and working hard to acquire ballistic missile technology.[33] If, as Richard Perle believes, Saddam Hussein is "a brutal megalomaniac ... who wouldn't blink at the mass destruction of his enemies," the United States and its allies must commit themselves not only to freeing Kuwait, but also to destroying the nuclear

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[32] See Irving Kristol, "When It's Right to be Wrong," Wall Street Journal, 24 March 1993.

[33] Wall Street Journal, 22 August 1990.

capabilities of Iraq.[14] Lack of commitment to this goal will only postpone future conflict.

If history provides any guidance to both the business world and to world politics it is to underscore the importance of leadership commitment. Without commitment to the removal of the nuclear threat from Iraq, proliferation could take an ugly turn. Without strong and sustained leadership, Total Quality Management efforts will fail.

TQM and Technological Advances in Weapons Development

The area where TQM is the most visible in relation to the United States' weapons complex is in the development of new weapons, specifically the development of new, rational weapons.

Rational Weapons

Development of new weapons is not necessarily a rational process. Despite years of formal education and training, weapons designers can exhibit fanciful behavior. In the late 1950s, a weapons designer at Lawrence Livermore National Laboratory sold a program to the United States Atomic Energy Commission to develop a nuclear-powered, nuclear-armed rocket. The project, code-named Pluto, was funded with millions of dollars and assigned a huge proving area at the Nevada Test Site. This weapon system had one great failing: the exhaust from the nuclear rocket engine was highly radioactive. Had the rocket ever been flight tested, it

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[14] Ibid

would have spewed radioactive debris over the course of its flight path. Worse, however, was what would happen when the rocket crashed—as it must at the end of a flight. The radioactive engines would disintegrate and contaminate a wide area around the crash site.

Project Pluto could have been avoided if Lawrence Livermore and AEC leadership had taken a long, hard look at the project. Rather than looking at the Pluto in terms of both environmental (or customer)[35] and technical issues, only the technical issues were considered. In the absence of well thought out projects and well-defined goals employing TQM techniques, projects such as Pluto can proceed without close scrutiny.[36]

Project Pluto offers another lesson for practitioners of Total Quality Management. The Pluto system was a marvel of simultaneous engineering. The propulsion reactors, nuclear fuel, guidance systems, and construction materials all had to be developed as the project progressed. Designers, engineers, machinists, and other scientists worked together to build the system. However, the simultaneous engineering efforts were separated from reality. The weapon was not integrated with its environment. As a result, the project had to be closed.

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[35] Although often cited as a key TQM principle, "customer orientation" is actually part of the environment each organization operates in.

[36] U.S. News & World Report, 16 July 1990.

Practitioners of TQM must make sure that their efforts are compatible with their total environment and not simply efforts to increase efficiency and quality.[37]

Production of Quality Weapons

Recently, the United States Air Force contracted with the Boeing Co. for production of cruise missiles. Boeing in turn sub-contracted development of the navigational system for the missiles to Northrop Co. The projected use of the missiles, airborne launching, meant that each missile must perform properly after prolonged exposure to temperatures reaching -65°F. Performance is critical since each missile is designed to carry a multi-kiloton warhead. Boeing tested the navigational units and found that they would not operate at temperatures below -35°F. When Boeing informed the Air Force of the problem, the Air Force did nothing to fix the problem or even attempt to jointly solve the problem with either Boeing or Northrop. Instead, the acceptance standard was lowered. This action prompted a review by the Justice Department and charges that the Air Force, in collusion with Northrop, was trying to "cover up" a problem. During an ensuing congressional investigation, Northrop admitted that its units could not perform as required under the original contract.[38]

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[37] Herken, Gregg F., "The Flying Crowbar," Smithsonian Air & Space (April/May 1990), 28-34.

[38] Wall Street Journal, 27 July 1990 and 15 October 1990.

The Northrop story underscores the ongoing problems in the Defense Department's procurement program, and provides evidence that TQM might provide the government with a better way of doing business. The Air Force, as the consumer of Northrop's product, had the authority and the responsibility to closely monitor performance standards and to insist that these standards be met. Not only did Northrop ignore customer service, the Air Force forgot that it was the customer. Air Force monitoring is particularly important since its contractual arrangements with vendors often keep competition from weeding out inferior suppliers and products. In short the Air Force needs to develop a cooperative approach that will insure quality, not promote "cover-ups." Such an approach is much like the Japanese kan-ban system. If a supplier does not meet quality standards, it is given an opportunity to correct deficiencies or is replaced.

SUMMARY

History, particularly the history of science, has some important things to say about how technical organizations can be managed. The most obvious message is that TQM works and works well. Multidisciplinary teams, simultaneous engineering, and conflict management all can be used to achieve difficult goals. It also is obvious that TQM principles can be applied successfully to most technical organizations. TQM is not a set of techniques for only service organizations. What is perhaps not so obvious is that TQM is not a cookbook for success. Each leader must find those specific TQM principles and techniques that fit the organization. Oppenheimer realized early on that his laboratory mirrored the culture of a university laboratory and not that of industry. He therefore championed open communication. Had he not resisted Groves' attempt to compartmentalize Los Alamos, the Laboratory would not have achieved the success that it did.

The final lesson that can be gleaned from the Los Alamos experience with Total Quality Management is that TQM works best when there is a clearly defined organizational goal. Goals are defined by the environment. During World War II, the Laboratory had a clearly defined goal—to build a fission device to help end the war. When TQM is separated from clearly defined goals and the environment—as was Pluto Project—TQM cannot guarantee success.